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SOME IMPORTANT FACTS IN THE LIFE HISTORY OF THE GID PARASITE AND THEIR BEARING ON THE PREVENTION OF THE DISEASE.

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It appears from correspondence received by the Bureau of Animal Industry that considerable doubt exists in those sections of the country where gid is prevalent as to the correctness of the generally accepted life history of the gid parasite. These doubts are harbored by veterinarians and by sheepmen, the persons on whom the prophylaxis of gid depends, and if disbelief on their part is followed by a disregard for those measures on which the prevention of gid depends, a continuation and spread of the disease may be confidently expected.

The life history of the gid parasite is essentially as follows: The adult parasite, a tapeworm, develops in the small intestine of the dog, and on attaining sexual maturity produces thousands of small eggs which are contained in the posterior segments. These segments are passed with the feces usually; perhaps at times single segments or chains of segments escape or are expelled without feces, and under proper conditions of temperature and moisture these rot and liberate the eggs. Such eggs as in this way attain a favorable location on herbage where sheep are pastured, or in water which sheep drink, may be taken into the digestive tract of the sheep with food or water, the hard shell digested off, and a minute embryo liberated. This embryo bores its way through the walls of the digestive tract by means of the six hooks with which it is armed, and apparently bores finally into a blood vessel, along which it is swept with the blood current until it lodges. It may develop at this point, or it may

start an active migration through the tissue in which it lodges and start to develop after traversing a short space. In the brain and spinal cord the embryo grows into a larval cestode known as a bladder-worm, consisting of a membranous sac on which numerous tapeworm heads develop. In all other situations the embryo starts to grow, but almost invariably degenerates and dies in a short time. If the bladder-worm in the brain or spinal cord is ultimately eaten by a dog, the sac will be digested but the tapeworm heads will pass unharmed to the intestine, where they will gradually develop segments until each head has formed a complete tapeworm ready to reinfect the food and drink of sheep.

This life history of the gid parasite is not at all a matter of speculation and rests upon no uncertain basis. It was first completely demonstrated by Küchenmeister (1853e)[a] by feeding the brain bladder-worm from the sheep to the dog, and eggs from the dog tapeworm to the sheep, and it has since been confirmed in numerous cases by workers in Germany, France, Italy, England, and Scotland, and by Ransom and the writer in the United States. The larval parasite is commonly recorded from sheep which have not been the subject of experiments, but can be produced at will by feeding the eggs of the adult tapeworm. The adult worm is commonly recorded as produced by feeding experiments, but has been often recorded as found in dogs not the subject of such experiments. Additional proof of the correctness of our knowledge of the life history has been furnished by a number of observations, such as those of Heitzmann (1868a), where the duration of gid in a given flock has been coextensive with the employment of dogs infected with tapeworms, and the cessation or diminution in extent of the disease has coincided with the removal of these dogs or their treatment for and removal of the tapeworms.

The objections which have been raised to the life history as given are that it is improbable that dogs could get at the brain through the skull of giddy sheep, and that in actual practice they do not do so. At first thought the argument that a dog could not get at the brain of a giddy sheep seems very plausible—in spite of the fact that we are accustomed to see a dog crush the femur of an ox to get at the bone marrow—and the statement of a reputable veterinarian in Montana that according to his observation such would be an extremely exceptional case, and that sheepmen of long experience are unanimous in the opinion that dogs do not at any time eat the brains of sheep, lends additional weight to this argument.

[a] For a complete reference to this article and to other articles by various authors cited in the present paper the reader is referred to Bureau of Animal Industry Bulletin 39, Index-Catalogue of Medical and Veterinary Zoology.

The argument that the brain of sheep is practically inaccessible to dogs is not a new one. Five years after Küchenmeister (1853e) had demonstrated the life history of the gid parasite, Reynal (1858a) states that in those countries where gid is prevalent the sight of a dog eating the heads or the brains of sheep dead of gid is not so common as one might believe. He further urges that it is difficult for him to believe that the gid parasite, protected by a bony case and located in an organ which decomposes readily, could be eaten in the great majority of cases.

It is evident that since one cœnurus will supply a dog with a large number of tapeworms, only a small proportion of the infected sheep heads needs to be eaten in any given season in order to keep up the infection.

Aside from this, if the objections to the dog's ability to eat sheep heads are sustained, the two obvious alternatives are that the brains are removed from the skull by people and either the brain containing the parasite or the parasite itself fed to dogs or thrown where dogs and other carnivora have access to them, or, as has been suggested to the Bureau in correspondence, that the cœnurus develops in the body of the sheep outside of the brain and spinal cord as well as in these locations.

Küchenmeister (1853e) found on investigation in Germany that some people were accustomed to taking out the brains of giddy sheep and feeding them to the dogs, and Heitzmann (1868a) notes instances where the cœnurus itself was extracted from the brain and fed to the dogs. It would not be surprising to learn that sheep owners or herders in this country had made this same mistake. Evidence is not wanting to show that these customs have not yet disappeared from Germany after more than half a century of education on this subject, and gid as an economic problem is of comparatively recent date in this country.

That the gid parasite should develop in the sheep outside of the central nervous system to the point where it would be capable of infecting the dog, and that helminthologists should be unaware of it, is altogether out of the question. In all of the numerous experimental demonstrations of the life history made in this country and abroad, the parasites recovered by careful post-mortem examination of the parts outside of the central nervous system of the sheep have always been found aborted. The parasites of few, if any, animals have been studied more than those of the sheep, and the gid parasite especially has received a great deal of attention. The idea that well-developed cœnurus forms should occur outside of the central nervous system with such frequency as the objections call for, and go undetected in abattoir inspection and post-mortem inspection of other sorts, is not

in the least tenable. The extensive literature of gid available in Washington shows that the occurrence of a cœnurus, said to be the gid parasite, in subcutaneous situations in sheep has been claimed once by Eichler (see Leisering 1859a) and once by Von Nathusius (see Leisering 1862a), the occurrence of cœnuri of the same species in the thyroid, lymph glands, and musculature of *Hippotragus equinus* has been claimed once by Rabe (1889a), and a very doubtful case of a cœnurus, stated as probably *Cœnurus serialis*, from a subcutaneous situation in a horse in the United States, is noted by Stiles (1898a). Such cases are extremely exceptional and can be disregarded as negligible quantities in the prophylaxis of gid.

It is interesting to note that in the available literature there is no definite record of any observations on the eating of sheep heads by dogs. That they do so seems to be taken for granted or perhaps regarded as too well known or too self-evident to need demonstration or proof. And it is possible that on the European farms, where the flocks have smaller ranges and are more closely and carefully watched than is the case in our Western States, the facts in this case are well known. As has been stated, the fact that dogs will eat sheep heads does not seem to be generally appreciated in this country. The veterinarian to whom we have referred writes:

> In driving around over sheep ranches it is a common sight to see hundreds of sheep skulls lying around the pens, and it is rare indeed to find one where the bony structure has been broken sufficiently to permit the eating of the brain by the dog or coyote.

This sentence indicates the existence on sheep ranches of a condition extremely favorable to the spread of gid, and expresses by inference a belief, accompanied by an apparent justification, that prophylactic measures to prevent dogs and wolves from eating sheep heads are not well founded.

In view of this, the writer undertook an experiment looking toward answering the question as to whether dogs eat sheep brains when these are protected by the skull. A dog, part collie in breed and weighing 25 pounds, was fed the head of a 10-month-old lamb on the morning of December 3, 1909. In order to expedite matters the head was skinned and the eyes and tongue removed. The next morning the dog had eaten the nose back to the nasal bones, broken off the jaws, licked the eye orbits, and had cracked off a piece of bone the size of a quarter (about 2.5 cm. in diameter) from the base of the skull adjacent to the foramen magnum, thereby exposing the base of the cerebellum. In doing this, what there was of the spinal cord, together with the medulla oblongata, had been eaten, but the cerebellum had not been touched. The skull was taken from the dog and left in the ice chest at a temperature of 10° to 15° C. for

five hours, when it was again fed to the dog. The next morning all that remained of the skull were two small pieces of bone, one being the back part of one lower jawbone, and the other the back part of the two upper jawbones with a part of the palatine connection between them. The rest of the skull and all of the brain and muscles had been eaten.

The evening of this same day, December 6, the head of another 10-month-old lamb was fed to the dog, the head being skinned and the tongue removed. The next morning it had hardly been touched. It was put on ice till evening and fed again. The next morning the head seemed on first sight untouched. Examination showed, however, that the dog had cracked off a small piece of bone from the foramen magnum forward to near the posterior root of the zygomatic arch, and with this comparatively small opening had licked out the entire brain with his tongue. The rest of the skull and the meat were untouched. From his experience with one sheep head the dog had developed a preference for sheep brains and had hit upon a method for getting them through a very small opening in the skull.

We may safely apply these experimental findings to field conditions. The dog used in the experiment was a common stray dog which had been picked up in Nevada and shipped here in connection with an experiment. The breed was well suited to the purpose of this experiment, and the size of the dog was no greater than that of western sheep dogs. The lambs were of suitable age, as sheep are usually subjects of gid during the first year of life—a time, be it noted, when the skulls are not as thick as they become later. The fact that the sheep head was skinned and the tongue, or the tongue and eyes, removed, merely served to hasten matters, but not to alter sensibly the bearing of the experiment on the question at issue. The absence of a cœnurus from the brains used gives additional weight to the experiment, if anything. The dog used had previously been fed several cœnuri of a species related to the gid parasite and had apparently relished them, and this is in line with the experience of other experimenters. Moreover, the presence of a cœnurus is very commonly accompanied by a thinning or perforation of the bone over the parasite, and this would make the brain more, and not less, accessible. Numan (1850b) has noted the skull of a giddy sheep with 22 such perforations. Such a skull would be easily crushed.

The reasonable conclusion from the experiment is that dogs have both the inclination and the ability to eat the sheep brain even when the brain is protected by the skull. The difficulty of getting at the brain is not extreme, but only supposedly so.

The casual observer, seeing on the range such remnants as were left of these two sheep heads, either just as the dog left them or as

they would look six months later, would never surmise that a dog had eaten the brains. There was too little of the first skull and too much of the second to suggest this. Unsupported by experimental evidence, the suggestion that a dog would lick out a brain through a slight enlargement of the foramen magnum might seem rather far-fetched.

The experiment suggests that the reason sheep skulls showing evidences of having been broken into by carnivorous animals are not seen on ranches is that dogs and perhaps other animals which prefer to feed in seclusion might unobserved reduce sheep heads to such small dimensions that the remaining portions would be overlooked or not connected with the eating of the brains by carnivora. It seems likely that a taste for sheep brains would be developed, and that carnivorous animals might commonly employ a scheme for getting at the brain similar to that utilized by the dog in the experiment. The dog used in this experiment was not very hungry. He had been well fed previous to the experiment, and the sheep heads simply replaced his accustomed meals.

The opinion has been expressed by correspondents that precautions to prevent dogs or wolves from eating the heads of dead sheep would be unnecessary in the winter time in States like Montana, where the disease is prevalent, on the assumption that the gid parasite would be promptly frozen and killed. It is true, as Perroncito (1885b) has shown, that freezing will kill the gid parasite. On the other hand, the protection afforded by the brain, the skull, and the skin, and the retained animal warmth would insure against immediate freezing even in very cold weather. Furthermore, the nature of the gid disease is such that giddy sheep must contribute a large percentage to the number of strays which fail to return because they have fallen a prey to dogs or other carnivora and have been eaten before freezing could possibly be a factor in the case. As a matter of fact, the fully developed gid parasite, capable of infecting the dog, is most common in spring when the weather is milder.

In this connection it should be noted that the dog is the only host in which the adult gid parasite is positively known to occur. It has never been found among the coyote tapeworms from Montana examined at this laboratory. However, very few coyote tapeworms have been examined, and it is quite probable that not only coyotes, but other wolves and foxes also, none of which have ever been definitely proved to be a host of the gid parasite, may nevertheless harbor this tapeworm. It would be no mistake to kill these animals as possible carriers of gid, as well as on other grounds, and the useless, ownerless dogs should be put in the same category. Incidentally, it would be advisable to bury such dead carnivora to avoid infecting pastures

from the decomposing intestines, a possibility suggested by Küchenmeister (1853e).

In conclusion, the prophylaxis advocated in the previous publications of the Bureau of Animal Industry by Curtice (1890c), Stiles (1898a), and Ransom (1905d) should be rigorously adhered to. This prophylaxis, based on the life history as given, consists essentially in interrupting the cycle of the parasite's development at the points where it is most easily attacked. In practice, this consists in the destruction of the gid parasite from the brains of sheep dying of gid and in allowing on the pasture only such dogs as are necessary, and keeping these free of tapeworms. The parasite in the brain is best destroyed by burning, or if the heads are needed as food for the dogs, they should be subjected to prolonged boiling. Buried heads are liable to be dug up. As the adult tapeworm develops in the dog in four to eight weeks as a rule, the utmost precaution would demand vermifuge treatment every month or two. In practice it seems probable that routine vermifuge treatment four times a year, and oftener when it was evident that a dog was infected, would eliminate the disease, especially if particular care were taken to free the dogs of worms in the spring when the outbreak for the year is over and there are no more giddy sheep heads available.

A discussion of other prophylactic measures is reserved for a future time, when field studies and experiments have shown their applicability to the local conditions involved.

Approved:

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Secretary of Agriculture.

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